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Model Improvement for ADMS Deployment

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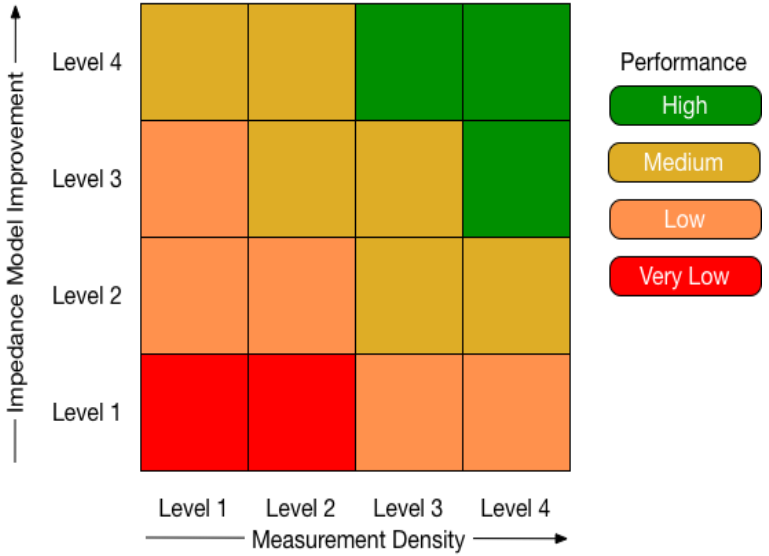
Objective

Evaluate the performance of the advanced distribution management system (ADMS) Volt/VAR Optimization (VVO) application for different levels of model quality and different levels of measurement density

- 4 different load days
- VVO optimized for conservative voltage regulation (CVR)
- Six feeders from Xcel Energy



Model Quality for ADMS Deployment

- Model quality is essential for accurate ADMS performance.
- A geographical information system (GIS) is a typical source for ADMS.
- Model and data cleanup = up to 25% of ADMS costs.
- Upkeep of models during operation is a critical need.
- Xcel Energy is modernizing its distribution grid.

Important Questions

- What level of data cleanup needs to be performed for successful deployment?
- Can the need for data cleanup be offset by deploying additional sensors?
- Can sensors such as advanced metering infrastructure (AMI) be used in addition to supervisory control acquisition (SCADA) points to improve ADMS performance?
- What is the impact of the reduced data quality on the performance of ADMS and its applications?

Levels of Model Quality

Level 1 – Base-level data extracted from the Xcel Energy GIS

Level 2 – Field verification occurs at select locations to obtain wire size where unknown, obtain or confirm step transformer attributes, and collect capacitor, regulator, and recloser attributes

Level 3 – Tap phase verifications

Level 4 – Field confirming each primary pole line by circuit to obtain distribution transformer attributes, phasing, and using Xcel Energy GIS data to: a) identify new assets not shown in GIS; or b) identify assets no longer existing in the field

Levels of Measurement Density

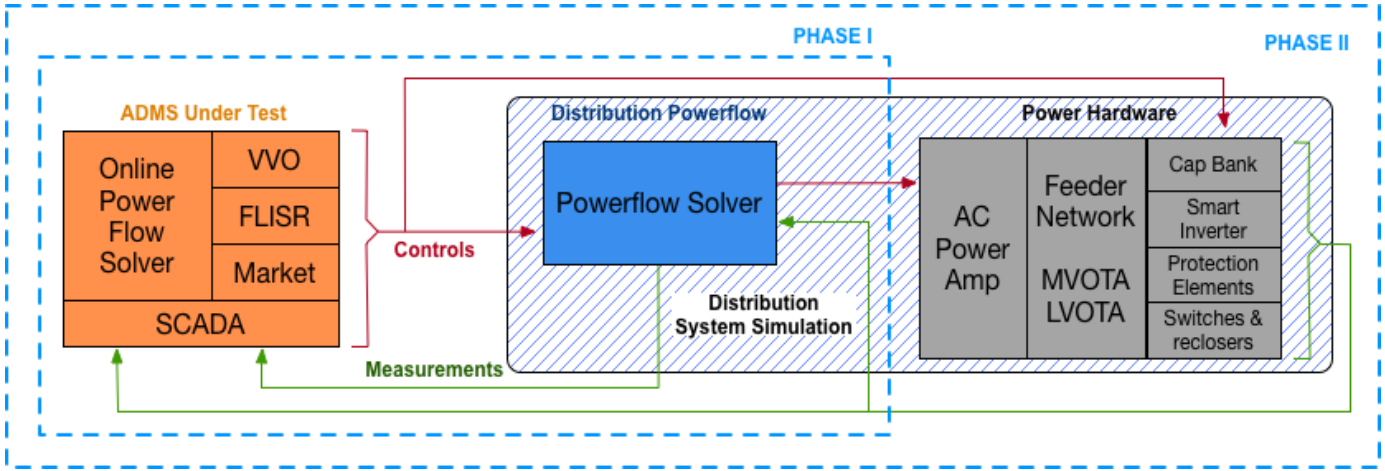
Level 1 – Feeder head measurements

Level 2 – Measurements from Level 1, voltage regulators, capacitor banks, reclosers, and 1 tail-end voltage sensor (AMI sensor) per feeder with communications

Level 3 – Measurements from Level 2 and a total of 10 AMI sensors per feeder

Level 4 – Measurements from Level 2 and a total of 20 AMI sensors per feeder

Test Setup



Phase I: Software-based simulations

Phase II: HIL-based evaluation

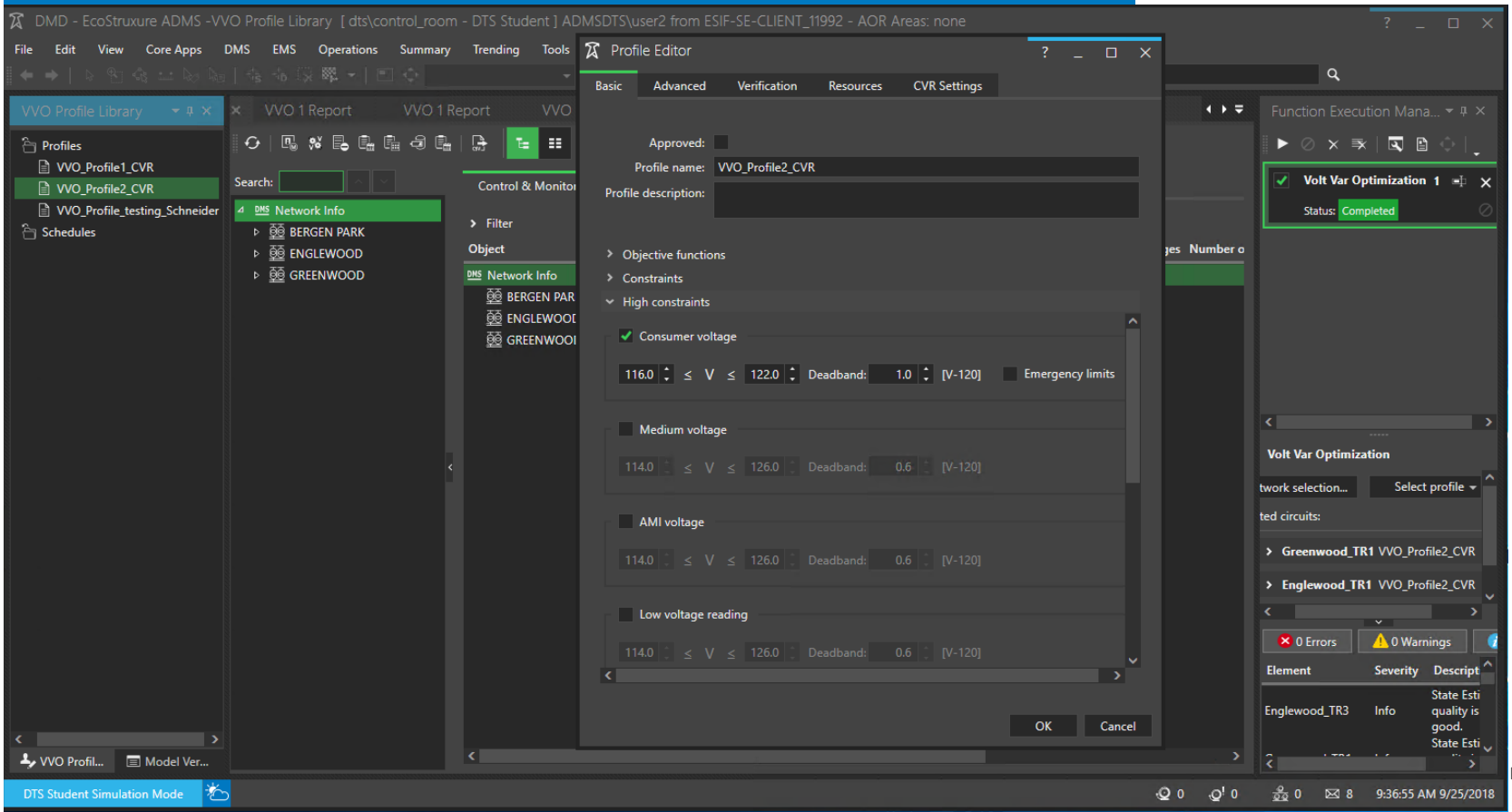
Test Plan

Test Setup – ADMS Configuration

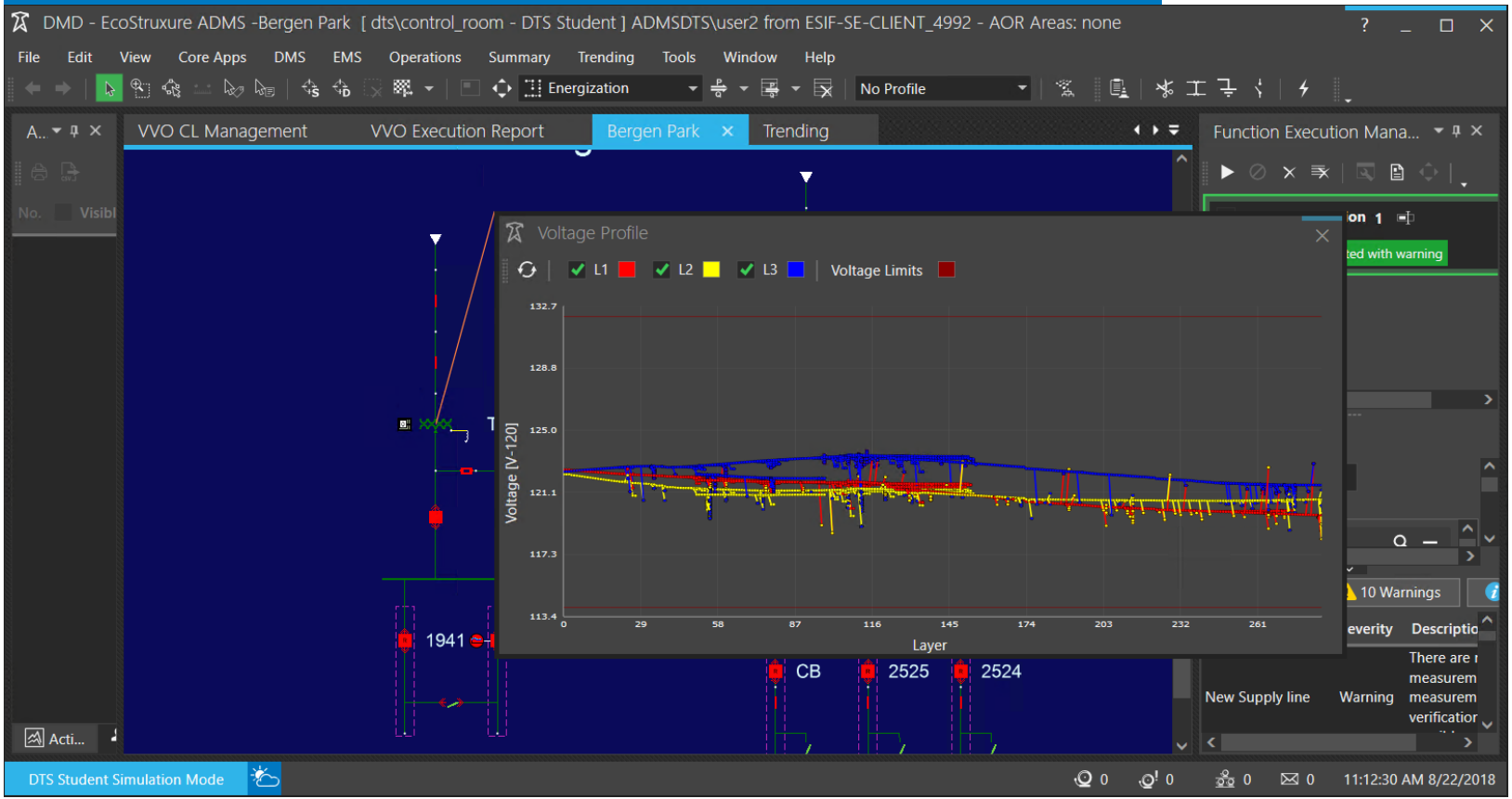
Configure the ADMS

- Load ADMS with selected data representing a certain level of data remediation and measurement density
- Configure the ADMS's SCADA application based on the level of measurement density
- Configure VVO application with the selected objective and constraints
- Run VVO application for a selected daily profile
- Enable data collection and post-processing blocks (SQL and Python scripts)
- Compute and record necessary performance metrics
- Repeat tests with varying levels of data remediation and measurement density and for different days

ADMS Configuration



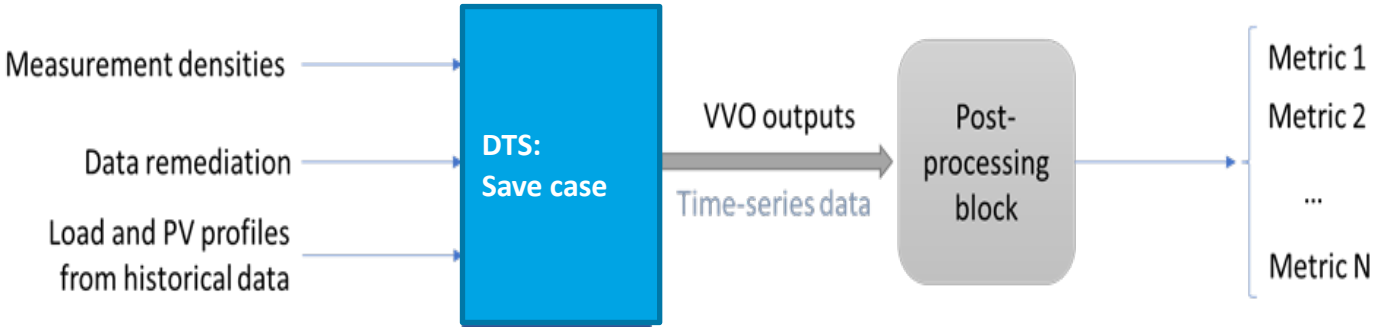
ADMS Configuration



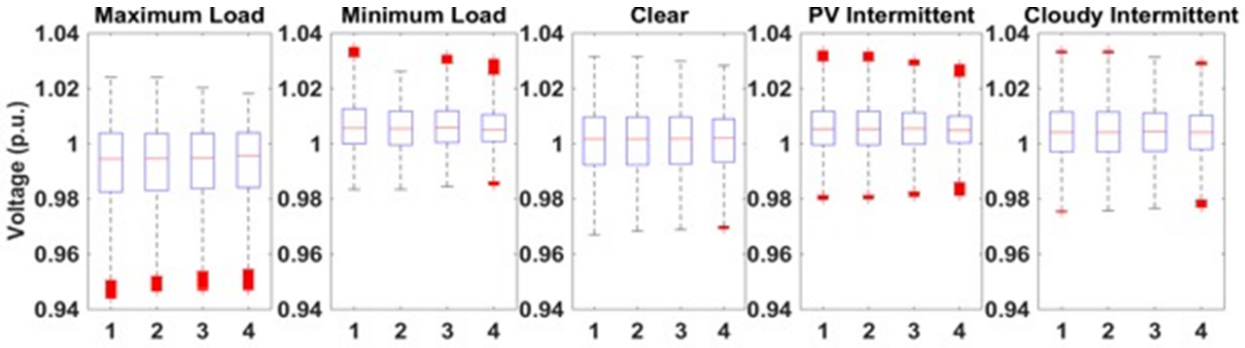
Test Metrics

Test Metric	Description
CVR Energy Reduction	Feeder energy consumption before and after application of CVR
Voltage violation Magnitude Index	Average of voltage magnitude violations for selected/all nodes over the time period beyond predefined limits
Voltage Violation Frequency Index	Percentage of time steps when voltage limits violation occurs at any of the nodes
System Average Voltage Fluctuation Index	Average voltage fluctuations for all nodes within the time period. Represents the flatness of the voltage profile.
System Control Device Operation Index	Number of times the capacitor banks were turned on or off
Capacitor bank operations, load-tap changing (LTC) or voltage regulator operations	Number of times the LTC/voltage regulators were operated
System Energy Loss Index	Ratio of total energy loss during the entire simulation time to the total load demand
Cost of operation	Costs of voltage regulation from operation of capacitor banks, regulators, etc.
Power factor	Power factor computed at selected nodes

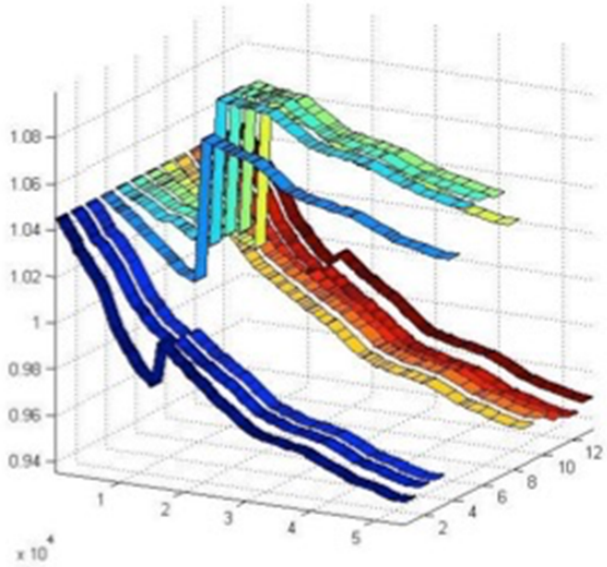
Metrics Calculation



Metrics: Other Examples



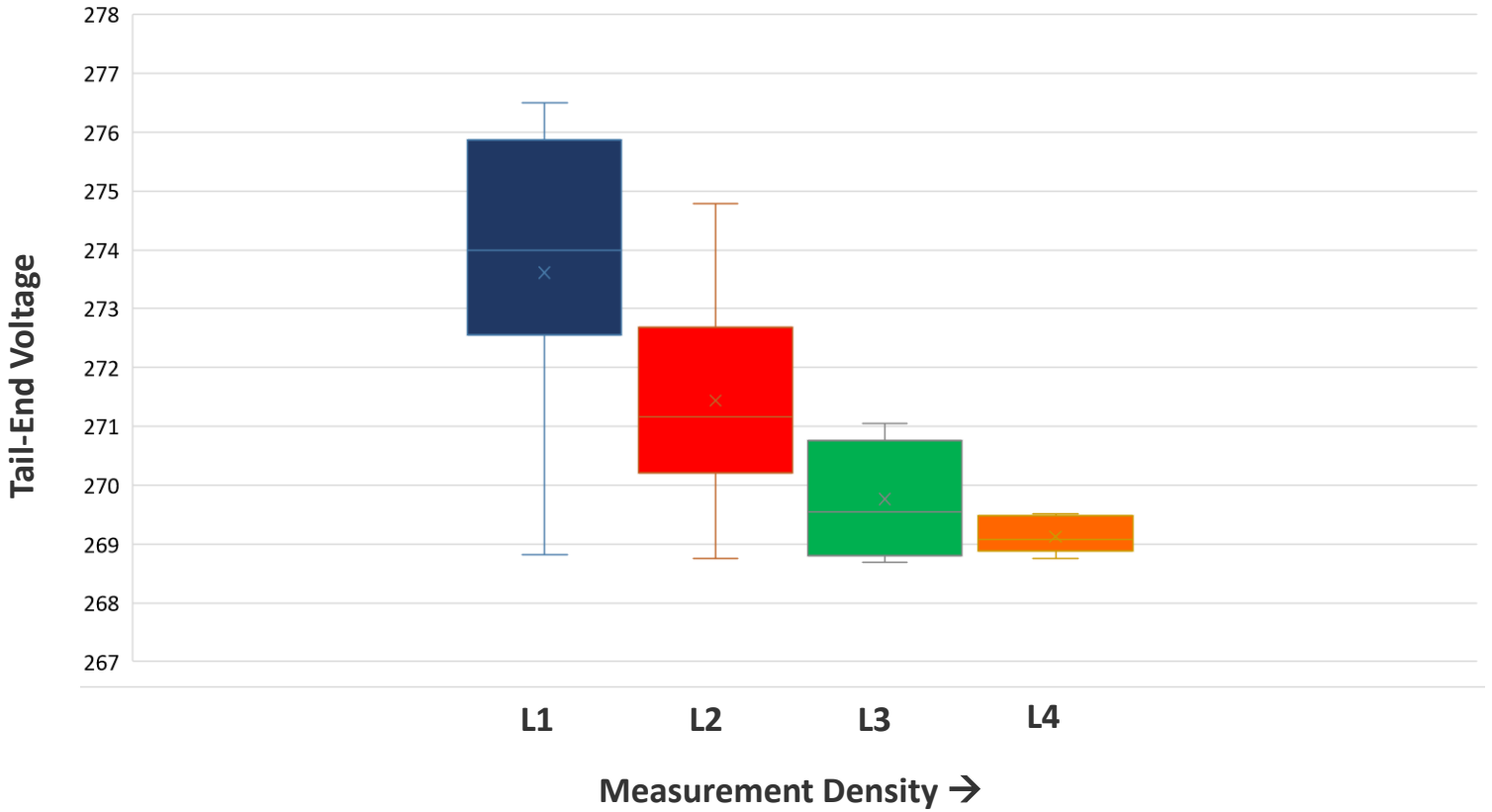
Voltage range and standard deviation for 1) unity power factor, 2) Volt/VAr curve-1, 3) Volt/VAr curve-2, and 4) Volt/VAr curve-3. Data in red indicate values beyond 1.5 times the interquartile range.



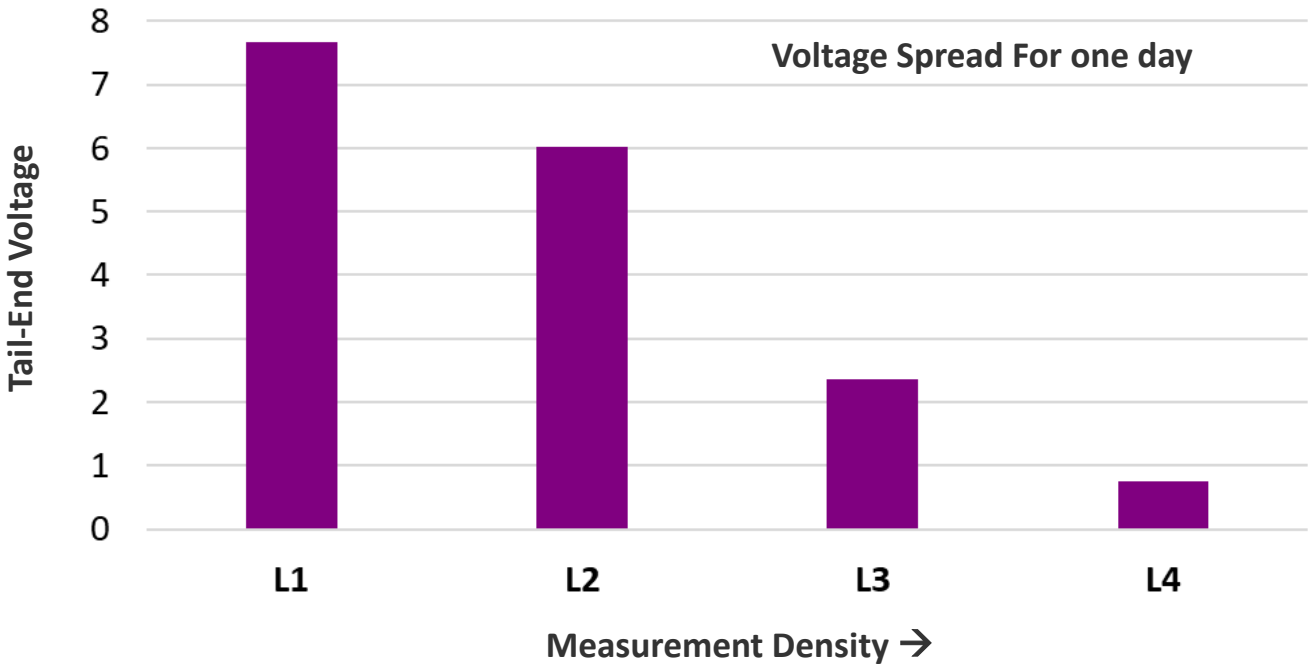
Initial Results

The results are preliminary until verified using other metrics and other feeders.

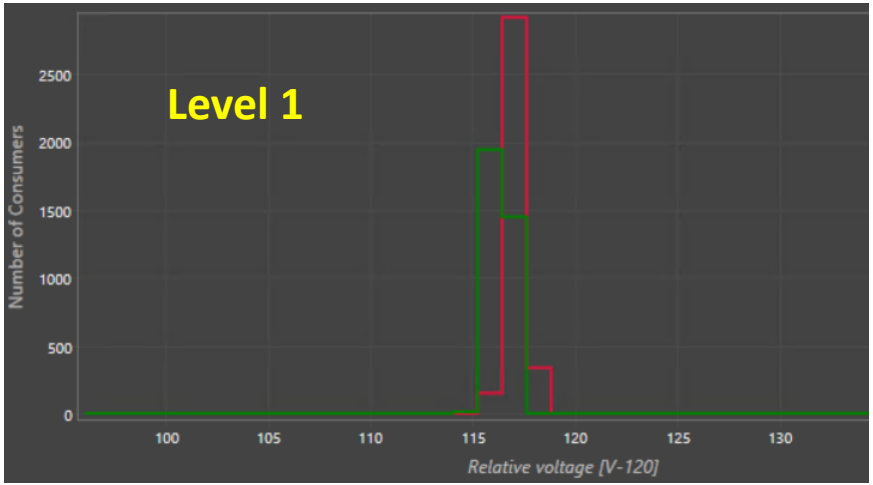
Performance Against Measurement Density

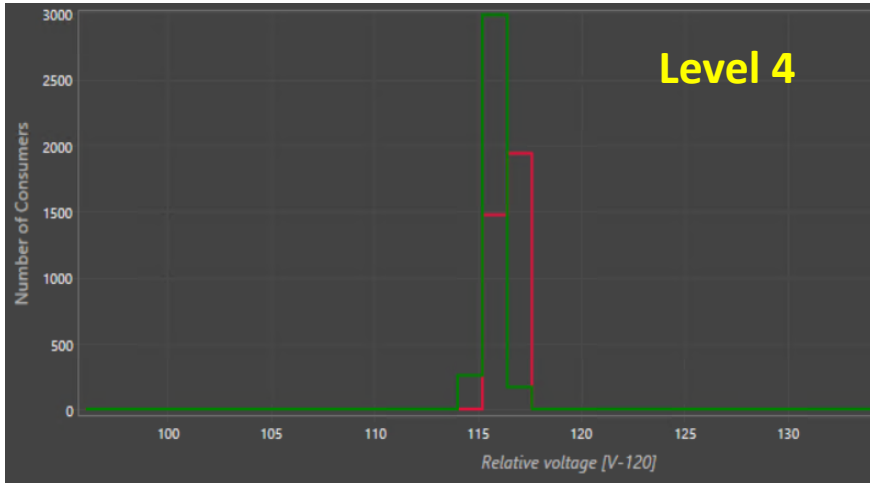


Performance Against Measurement Density



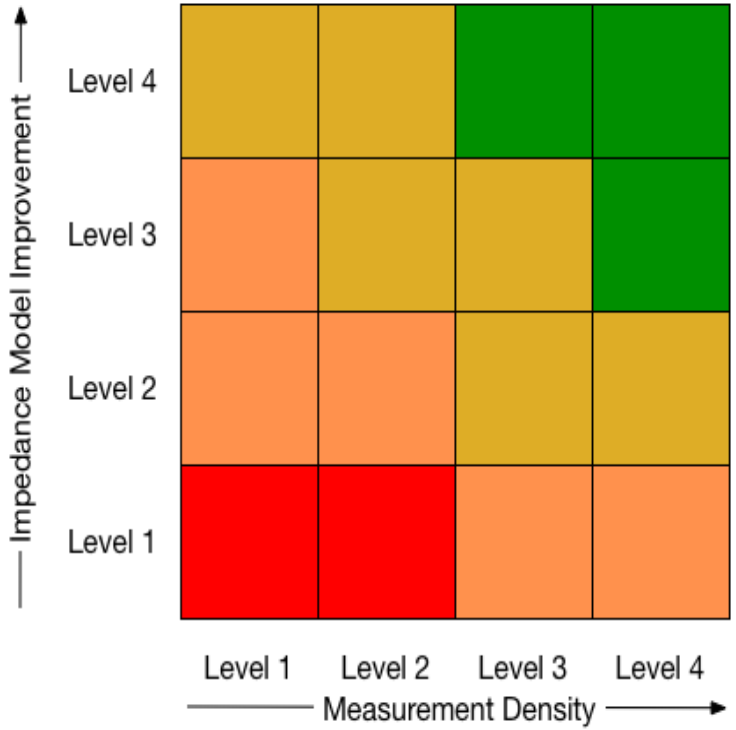
Performance Against Model Quality





Next Steps

- Adjust load scaling to emulate different loading levels
- Generate other metrics with the data collected from the experiments
- Capture feeder characteristics and performance
- Quantify impact on deployment costs



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Thank you

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